International Journal of Information and Computation Technology.
ISSN 0974-2239 Volume 4, Number 3 (2014), pp. 231-238
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Augmented Reality: Its Applications and Use of Wireless Technologies

Prabha Sharma

UIET, PUSSGRC, Hoshiarpur.

Abstract

Augmented reality(AR) is a relatively new technology that allows mixing virtual with real world in different proportions to achieve a level of immersion that no virtual equipment can provide. Recent advances of computer and vision technology make possible AR systems to go beyond indoor applications (e.g. surgery and inspection of hazardous environments) to support complex analysis, decision-making and governing processes. A new breed of computing called “augmented ubiquitous computing” has resulted from the convergence of wearable computing, wireless networking and mobile AR interfaces. A survey of various technologies can help us to understand the state of an art and to help identify new directions of research.

Keywords: Augmented-mixed reality, wireless networking.

1. Introduction

Augmented reality (AR) is the integration of digital information with live video or the user's environment in real time. Basically, AR takes an existing picture and blends new information into it. Very often AR is defined as a type of “virtual reality where the Head Mounted Display (HMD) is transparent”. The goal of augmented reality systems is to combine the interactive real world with an interactive computer-generated world in such a way that they appear as one environment. As the user moves around the real object, the virtual (i.e. computer generated) one reacts as it is completely integrated with the real world. Furthermore, the virtual object may move but still the movements are registered with respect to the real world. Fig. 1 shows three examples of AR views, a static view of a brain, a virtual car moving around the monument and a virtual Packman “jumping” in an office. Some of the many actual or potential uses of augmented reality:

- The changing maps behind weather reporters.
- A navigational display embedded in the windshield of a car.
- Visual displays and audio guidance for complex tasks.
- Images of historical recreations integrated with the current environment.
- A display in a pilot's helmet that allows the pilot to, in effect, see through the aircraft.
- Mobile marketing involving product information displayed over that product or its location.
- Video games with digital elements blended into the user's environment.
- Virtually trying on clothes through a webcam while online shopping.
- Displaying information about a tourist attraction by pointing a phone at it.

Wireless AR systems face three fundamental problems. The first one is the manner of mixing real and computer-generated environments (i.e. alignment of virtual and real objects). An AR system should provide the user with a perception of an integrated working environment (Fig. 2). Depending on the approach used, the AR systems can have several forms and can be classified into different groups. Another critical issue in AR systems is tracking (determining the position, direction and speed of movement) of the mobile user. The third problem is related to the wireless communication between users and backbone computers.

Fig. 1: Examples of AR views: brain on a real human head, a virtual car in a real square (LORIA), Packman in the office.

While alignment of virtual and real objects is a specific AR issue, tracking of a mobile user and wireless communications are well know issues in VR systems and LBS. Therefore, for survey on wireless AR systems some familiarity for Virtual reality systems and Location based services is required.

Fig. 2: Head Mounded Display (HDM), Glove Input Device and CAVE.

1.1. AR as a mixed environment

Firstly, a vision of Mixed Reality (reality-virtuality continuum) is used to clarify the link between AR, VR and the real world. Secondly, the understanding of VR is commented to provide a background for discussion on similarities and differences with AR. Azuma et al [2] have surveyed the MR continuum that included the notions of VR, AR and AV (Augmented Virtuality).

1.1.1. Reality-virtuality continuum

Milgram et al [6], introduce the reality-virtuality continuum that defines the term mixed reality and portrays the "link" between the real and the virtual world (Fig. 3). If the real world is at one of the ends of the continuum and VR (i.e. computer-generated, artificial world) is at the other end, then the AR occupies the space closer to the real world. The closer a system is to the VR end, the more the real elements reduce. For example, the AR systems using Optical See-through Displays are placed closer to the real world compared to AR systems with Video-mixing (Fig. 3). If the real world can be augmented with virtual objects, it is logical to expect that the virtual world can be is augmented with real scenes (views, objects). Such an environment is called augmented virtuality. On the reality-virtuality continuum, AV occupies the space closer to the VR environments.

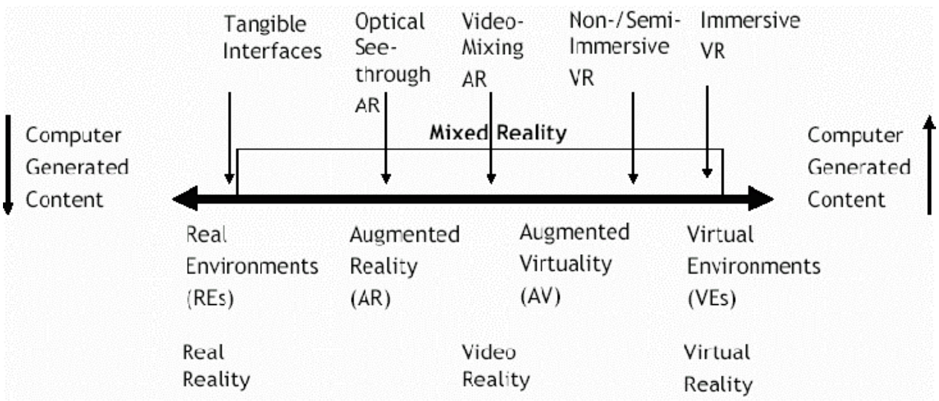

Fig. 3: Reality-virtuality Continuum (Milgram and Kishino 1994).

1.1.2. Virtual Reality

The term virtual reality has a different meaning for different people. There are people to whom VR is a specific collection of technologies such as Head Mounted Display (HMD), Glove Input Device and Cave (Fig. 1-2). Perhaps the best (and shortest) description of virtual reality as a “...way for humans to visualise, manipulate and interact with computers and extremely complex data” .The visualisation is understood in a broad sense as some kind of sensual output.

1.1.3. Classification of AR systems

Similarly to VR systems, different classifications of AR systems can be made focusing on hardware of the AR system (e.g. the type of tracking system), or visualization approaches (see-through, video-mixture) or working distance (indoor, outdoor) or communication (wireless, hardwired). The most well known classification is related to the visualization approach, i.e. the way the mixture is provided to the user. The reality-virtuality continuum diagram shows these two very general classes of AR systems, i.e. Optical See-through and Video-mixing(Fig.1.3). These may have several variances with respect to where the images (objects) are visualized, i.e. on a desktop screen or on a HMD. The following two sections elaborate on classifications based on the type of display and the range of the AR systems.

1.1.4. Displays

To be able to augment real or virtual worlds apparently some sort of displays (the terms is used in a broad sense) are needed. Milgram et al, 1994 distinguish between several classes of existing hybrid display environments, on the basis of which reasonable clarification of the AR systems can be done:

1. Monitor based (non-immersive) video displays–i.e. "window-on-the-world" (WoW) displays–upon which computer generated images are electronically or digitally overlaid. Practical considerations very often draw the attention to systems in which this is done stereoscopically. 2. Video displays as in Class 1, but using immersive HMD's, rather than WoW monitors. 3. HMD's equipped with a see-through capability, with which computer generated graphics can be optically superimposed, using half-silvered mirrors, onto directly viewed real-world scenes. 4. Same as 3, but using video (rather than optical) viewing of the real world. The difference between classes 2 and 4 is that with 4 the displayed world should correspond orthoscopically with the immediate outside real world, thereby creating a "video see-through" system. 5. Completely graphic display environments, either completely or partially immersive, to which video "reality" is added. 6. Completely graphic but partially immersive environments (e.g. large screen displays) in which real physical objects in the user's environment play a role in (or interfere with) the computer generated scene, such as in reaching in and "grabbing" something with one's own hand.

We can combine the classes from one to 4 in two simpler classes of AR systems, i.e.:

Monitor based AR (MB_AR) systems (class 1). See-through AR (ST_AR) systems, i.e. either video or reality (classes 2,3,4). Class 5 displays refer to a technique in which what is being augmented is not some direct representation of a real scene, but rather a virtual world (i.e. generated by computer), it refers to AV, as depicted in Fig. 1-3.Class 6 displays go beyond all other classes in including directly viewed real-world objects.

1.1.5. Range/distance

One very important distinction between different systems has to be made with respect to the area they can operate on. Outdoor AR needs to use absolute or relative positioning systems, in combination with vision systems when the accuracy is not sufficient. Outdoor application usually need a special transmission channel, which either has to be developed or existing communication services have to be used.

2. Wireless Networking for Mobile AR

Wireless network characteristics differ quite markedly from wired in latency, bandwidth, bandwidth fluctuations and availability. These have direct impact on the performance and quality of user experience in AR. In addition, there are many different types of wireless networks available. These impact the types of applications that can be developed. To support a usable AR system, a wireless network should provide sufficient data rate, low latency and support for mobility. There are different types of networks that support these key requirements.

2.1 Wireless WANs and 3G Networking

The wireless wide area networks (WWANs) are ideal for AR systems that need to support large scale mobility, for example nation-wide or in a large city. Systems that provide location-based services are a good a very good example of such an application. To be useful the system needs to support large scale mobility.

2.2 WLANs

Wireless local area networks (WLANs), as the name suggests, are wireless networks implemented in a local area such as a home or an office building. WLANs typically will support much higher data rates (between 11-54 mbps) and lower latency than WWANs but their support for mobility is limited than in WWANs. Currently, WLANs can be built using any of the IEEE 802.11a/b/g/n standards compliant equipment. WLANs can be seen to be competing with 3G networks which are designed to provide WWAN capability .As the two wireless networking technologies begin to co-exist, it is useful to allow the VR environment to operate on whichever connection is connection is available at the time of operation and to be able to operate on cheaper connections.

2.3 WPANs

The wireless personal area networks (WPANs) are short-range (typically a few meters), high-bandwidth wireless networks used for applications such as printing, file transfer and remote control. Often WPANs are implemented using Bluetooth or infra-red communication technologies. In VR, WPANs have been extensively used in combination with PDAs to interact with 3D VR environments. To control 3D environments, users often need to provide inputs through buttons, sliders and menus. Such input can be provided through a handheld device which can communicate with the VR environment through WPANs. More recently, use of handheld devices and WPANs has been extended to interaction with real-world scenarios.

2.4 Tracking and Registration for Mobile AR

AR requires very accurate position and orientation tracking in order to align, or register, virtual information with the physical objects that are to be annotated. Without this, it is rather difficult to trick the human senses into believing that computer-generated virtual objects co-exist in the same physical space as the real world objects. There are several possibilities for classifying tracking methods. First, technological characteristics can be used to differentiate between the approaches. Another criterion is the applicability in different environments like indoor or outdoor, or the granularity of the determination of the position or the inclusion of the position together with the orientation within the physical space can be administered.A wide range of both visual and non-visual tracking technologies, such as magnetic and ultrasound, have been applied to AR as already described in recent surveys from Azuma et al [1], Azuma et al [4] and Hollerer [3].

Tracking with GPS, GSM, UMTS: Probably, the most predominant system for outdoors tracking is the Global Positioning System (GPS) . GPS is a time measurement based system and can be applied in almost all open space environments except narrow streets or covered sight to the sky due to trees or other obstacles to receive the signals from at least 4 satellites. The accuracy of the localization can vary between 3 and 10 meters depending on the satellite connection and the continuity of the navigation of the receiver. Other tracking ways are:a)Outside-in and Inside-out Tracking b)Visual Marker-based tracking[5] c) Visual Markerless tracking d)Sensor based tracking e)Wireless-LAN tracking f) Hybrid tracking systems

2.5 Displays

There are many approaches to displaying information to a mobile person and a variety of different types of displays can be employed for this purpose, such as, personal hand-held, wrist-worn, or head-worn displays; screens and directed loudspeakers embedded in the environment; and, image projection on arbitrary surfaces; to name but a few. Several of these display possibilities may also be used in combination. Augmented reality displays utilized in recent mobile AR systems can be fundamentally split into two categories: optical see-through displays with which the user views the real world directly (such as Micro-Vision Nomad, TekGear Icuiti or EyeTop), and video see-through displays with which the user observes the real world in a video image as acquired from a mounted camera (such as Trivisio AR-Vision and i-glasses PC). There are various issues associated with both types of display such as:) latency, resolutiondistortion, field of view and cost, as well as b) perceptual: depth of field, qualitative, and finally, c) human factors: social acceptance and safety. One of the current trends for mobile AR is the fusion of different display technologies with wearable computing (Hollerer [3]).

2.6 Wearable input and interaction technologies

Piekarksi [6] defines a wearable computer to be a self powered computing device that can be worn on the body without requiring the hands to carry it, and can be used while performing other tasks. It should thus be worn like a piece of clothing, as unobtrusive as possible. Key factors amongst others are comfort, weight, size, mobility, and aesthetics. How to interact with wearable computers effectively and efficiently is an area of active research. Mobile interfaces should try to minimize the burden of encumbering interface devices. The ultimate goal is to have a free-to-walk, eyes-free, and hands-free interface with miniature computing devices worn as part of the clothing.

3. Conclusion

After the basic problems with AR are solved, the ultimate goal will be to generate virtual objects that are so realistic that they are virtually indistinguishable from the real environment .Of course still important challenges lie in these areas as by reviewed literature:

a) Limited computational resources: b) Size, weight: wearable AR systems should not be a burden but as unobtrusive as possible c) Battery life: an important factor of the sustainability of the above AR applications. d) Ruggedness: all above mentioned mobile AR systems are early prototypes and depending on the display setup (handheld or HMD), device materials, cables, connectors and cases normally used indoors may be unsuitable outdoors. e) Tracking and Registration: these are the basic components of a mobile AR system as specified before. f)3D graphics and real-time performance: one of he limiting factors for rich mobile content was the absence of dedicated 3D processing units in mobile devices. g) Social acceptance and mobility: the miniaturization of devices as well as their aggregation into wearable systems will contribute to gathering social acceptance momentum. Mobility is tightly intertwined with social acceptance of future mobile AR systems h)Networked Media: with the increasing expansion in bandwidth new breed of audiovisual networked media applications are envisaged and mobile AR systems can profit significantly.

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